APPENDIX G

FATE AND TRANSPORT MODELING PROCEDURES

AOI 10: SUNOCO PHILADELPHIA REFINERY

PHILADELPHIA, PENNSYLVNIA

QUICK DOMENICO MODELING

G.1 INTRODUCTION

Fate and transport calculations were completed for groundwater in Area of Interest (AOI) 10 to evaluate potential migration pathways/potential impacts to receptors. Eight wells (W-1, W-12, W-23, W-28, W-31, W-32, W-33, and W-34) in AOI 10 exhibited concentrations of groundwater compounds of concern (COCs) above their respective MSCs. The COCs that were above the MSCs in these wells were modeled using the analytical results from the April 2011 groundwater sampling event, and the Quick Domenico Version 2 (QD) spreadsheet model developed by Pennsylvania Department of Environmental Protection (PADEP). Site-specific data was used to complete the fate and transport calculations, when available.

G.2 MODEL OVERVIEW

The QD Model is a Microsoft Excel spreadsheet application based on the analytical contaminant transport equation developed by P.A. Domenico in *"An Analytical Model For Multidimensional Transport of a Decaying Contaminant Species,"* Journal of Hydrology, 91 (1987), pp. 49-58. The QD model calculates contaminant concentrations at any down-gradient location after a specified interval of time. The model incorporates the processes of advection, first order decay, retardation, and dispersion to describe fate and transport of compounds. In addition, the QD model displays the results as a two dimensional chart to facilitate interpretation of the results.

G.3 MODEL LIMITATIONS

Limitations of the QD model include:

- Groundwater flow is assumed to be steady state, and one-dimensional;
- Aquifer properties are assumed to be reasonably uniform;
- Applicable only to unconsolidated aquifers;
- Intended for use primarily with dissolved organic compounds;

- Does not account for the transformation of parent compounds into daughter products as the result of biodegradation;
- Compounds are considered individually, and are assumed to not react with each other; and
- The contaminant source is limited to a single and continuous source concentration.

G.4 MODEL INPUT PARAMTERS

In preparation of this report, input values for the QD model were compiled from available site-specific data. When no site-specific data was available, estimated input values from the PADEP spreadsheet "Number Please! 2011" which is based on PA Code, Chapter 250, Appendix A, Table 5, or other acceptable literature sources, were utilized. The input parameters are discussed in detail in the following sections and are summarized in the input/output tables G.1 through G.4 in this appendix. An Excel spreadsheet interface was used to construct the QD simulations. This interface allowed the simulation of all relevant compounds at each well location to be constructed and saved in a single electronic file.

G.4.1 Source Concentration

Results of the April 2011 groundwater sampling indicated that three organic compounds (benzene, chrysene and naphthalene) and one metal (lead) were detected above their respective groundwater MSCs in shallow wells (W-1, W-12, W-23, W-28, W-31, W-32, W-33, and W-34). The potential for these compounds to migrate offsite (beyond property boundary or discharge to the Schuylkill River) was evaluated through the use of the QD model.

G.4.2 Distance to Location of Concern (x)

Distance to the Location of Concern (distance) for the current simulations is the distance required for each COCs concentration to fall below its respective MSC under steady-state plume conditions. The distance is iteratively entered using the Excel "Solver" Add-on in the QD model until the location where the COC concentration falls below the MSC is identified. This step is performed using a large simulation time of 1×10^{99} days to ensure that the plume has reached steady-state.

G.4.3 Dispersivity

Dispersivity is the tendency of a dissolved plume to "spread out" as it moves down-gradient.

- Longitudinal dispersivity (A_X) occurs in the direction parallel to groundwater flow;
- Transverse dispersivity (A_Y) occurs in the same plane as longitudinal dispersivity but perpendicular to the direction of groundwater flow; and
- Vertical dispersivity (A_Z) occurs in the upward direction, normal to the plane in which longitudinal and transverse dispersivity occur (Vertical dispersivity is usually negligible and is typically omitted from most QD analyses).

Dispersivity estimates are difficult to quantify and are commonly estimated from the following relationships:

1. A_X = X/10 (where, X is the distance a contaminant has traveled by advective transport)
2. $A_Y = A_X/10$
3. $A_Z = A_X/20$ to $A_X/100$ (generally, it is recommended that A_Z be a very small number (0.001) unless vertical monitoring can reliably justify a larger number. Additionally, a value of 0.0001 is suggested for uncalibrated or conceptual applications).

As stated above the value for A_Y was estimated to be 10 percent of A_X. A value of 0.001 was used as a value for A_Z. A longitudinal dispersivity of 200 feet was assumed which is also the longitudianal dispersivity used in the CCR.

G.4.4 Lambda

Lambda is the first order decay constant. It is determined by dividing 0.693 by the half-life of the compound. The value can typically be estimated for shrinking plumes by evaluating at concentrations versus time or distance. Lambda can also sometimes be estimated for stable plumes by evaluating concentration versus time using the methodology outlined in Buscheck and Alcantar (1995). Important considerations to estimating Lambda from site data include:

1. Are the measured concentrations along the centerline of the plume?
2. Are the measured concentrations the result of the single source area?
3. Are there no remedial systems and/or activities that effected the migration of the plume during the time interval of evaluation?

If the answer is yes to these questions, then the methodologies outlined in Buscheck and Alcantar may be utilized to estimate a site-specific lambda from site data.

Based on review of the available site data, the criteria necessary to calculate a site-specific lambda could not be met; therefore, a default value for lambda (when appropriate and available) was obtained from the PADEP spreadsheet "Number Please! 2011" which is based on PA Code, Chapter 250, Appendix A, Table 5.

G.4.5 Source Dimensions

Source width is the maximum width of the area measured perpendicular to the direction of groundwater flow. Source thickness is the thickness of the contaminated soils below the water table that contribute contamination to groundwater. In addition to the saturated zone, fluctuation in groundwater elevation may create a smear zone in the unsaturated portion of an aquifer. As an estimate of the thickness of the smear zone, average fluctuation can be used. Since no plumes have been delineated, a source width of 100 ft was used. The source thicknesses used was 60 feet (ft), which is the average saturated thickness of the upper unconfined aquifer based on cross sections DD-DD' and EE-EE.'

G.4.6 Hydraulic Conductivity (K)

The hydraulic conductivity of a geologic material is a measure of its ability to transmit water. A hydraulic conductivity of 4.64 ft/d was used in the AOI 10 QD simulations. This value was the average hydraulic conductivity of the fill/alluvium at the site, obtained from the CCR. The wells that were modeled are screened in the fill/alluvium.

G.4.7 Hydraulic Gradient

Hydraulic gradient is the change in hydraulic head relative to the distance between head measurement locations. The hydraulic gradient is measured parallel to the direction of ground water flow assuming horizontal flow and a uniform gradient. Using the groundwater elevations collected in April 2011, the hydraulic gradient value was estimated between W-31 and W-16 and is 0.0046. This hydraulic gradient was used in all eight QD simulations due the limited number of wells on AOI 10 that fall on or near the same flow path.

G.4.8 Porosity (n)

Porosity is measured as the ratio of the volume of void space in a geologic material to the total volume of material. A porosity of 0.35 was used in the fate and transport modeling and is based on historical geotechnical analysis of site alluvial sediments.

G.4.9 Soil Bulk Density (ρb)

Soil bulk density is the dry weight of a sample divided by the total volume of the sample in an undisturbed state. Soil bulk density can either be determined by a laboratory or by the equation

$$\rho_b = 2.65 * (1- n).$$

Soil bulk density value used in the fate and transport modeling was 1.72 gm/cm^3 which is based on historical geotechnical analysis.

G.4.10 Organic Carbon Partition Coefficient (KOC)

The organic carbon partition coefficient is chemical specific and was taken from the PADEP EP spreadsheet "Number Please! 2011" which is based on PA Code, Chapter 250, Appendix A, Table 5. Koc is chemical specific and can be found in the QD model input-out tables.

G.4.11 Fraction Organic Carbon (foc)

The fraction of organic carbon is the organic carbon content of a soil. A laboratory using ASTM methods can determine this value. Samples for organic carbon are taken from the same soil horizon in which the contaminant occurs, but outside of the impacted area. Since no site specific fraction of organic carbon data was available for the site, the fate and transport modeling used the model-recommended default concentration of 0.005, which is a conservative value based on the description of site soils.

G.4.12 Time (t)

'Time zero' is the point at which contamination was introduced into the aquifer. Time since 'time zero' is measured in days. The final simulation time of 1×10^{99} days was used to ensure that a steady-state plume was simulated.

G.5 OUTPUT DATA AND RESULTS

A spreadsheet for each well, for which a QD simulation was performed, is included at the end of this appendix (Tables G.1 through G.8). Table G.9 is a summary of the QD modeling results. QD model results indicate a low to negligible potential for impacted groundwater to migrate beyond the AOI 10 property boundary. The benzene concentration at W-33 of 250 ug/l has some potential to migrate slightly (about 100 ft) beyond the AOI 10 property boundary.

Table G.1
Quick Domenico
Fate and Transport Model Input and Output AOI 10
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

Project	2574601 - Sunoco Philadelphia Refinery
Prepared by	Terrance Stanley
Date Prepared	6/23/2011

Generic Input Parameters				Data Source
Source Identification (or Well ID)			**W-01**	
Sample Date			4/27/2011	
Source Width		ft	100	Delineated LNAPL (100' default if no plume is present)
Source Thickness		ft	60	Estimated from cross-sections DD-DD' & EE-EE'
Longitudinal Dispersivity	A_x	ft	200	From CCR QD Simulations
Transverse Dispersivity	A_y	ft	20.0	Quick Domenico User's Manual
Vertical Dispersivity	A_z	ft	0.0001	Quick Domenico User's Manual
Hydraulic Conductivty	k	ft/day	4.64	Alluvium
Hydraulic Gradient		ft/ft	0.0046	W-31/W-16 April 2011
Porosity		decimal fraction	0.35	Site soil analyses
Soil Bulk Density	ρ_b	g/cm3	1.7225	ACT 2 TGM Default
Fraction of Organic Carbon	f_{OC}	decimal fraction	0.005	ACT 2 TGM Default
Time		days	1.00E+99	Steady-State Conditions

Chemical Specific Input Parameters				Data Source
Sim 1				
Contaminant			benzene	
Source Concentration (mg/L)		mg/L	0.0200	4/27/2011
Lambda (per day)		day^{-1}	0.001	PADEP Number Please! 2011
KOC			58	PADEP Number Please! 2011

Output (Distance from Source Where Concentration Equals Respective Ground Water MSC)				
Contaminant	**Starting Concentration (mg/L)**	**GW MSC[1] Non-Residential (mg/L)**	**Predicted Concentration (mg/L)**	**Predicted Distance to Meet Non-Residential GW MSC (Rounded Upward to the Nearest foot)**
Sim 1 - benzene	0.0200	0.005	0.005	**80**

[1] ACT 2 TGM, Appendix A, Table 1 MSC for a Non-residential Used Aquifer with Total Dissolved Solids less than or equal to 2500.

Table G.2
Quick Domenico
Fate and Transport Model Input and Output AOI 10
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

Project	2574601 - Sunoco Philadelphia Refinery
Prepared by	Terrance Stanley
Date Prepared	6/23/2011

Generic Input Parameters				Data Source
Source Identification (or Well ID)			**W-12**	
Sample Date			4/26/2011	
Source Width		ft	100	Delineated LNAPL (100' default if no plume is present)
Source Thickness		ft	60	Estimated from cross-sections DD-DD' & EE-EE'
Longitudinal Dispersivity	A_x	ft	200	From CCR QD Simulations
Transverse Dispersivity	A_y	ft	20.0	Quick Domenico User's Manual
Vertical Dispersivity	A_z	ft	0.0001	Quick Domenico User's Manual
Hydraulic Conductivty	k	ft/day	4.64	Alluvium
Hydraulic Gradient		ft/ft	0.0046	W-31/W-16 April 2011
Porosity		decimal fraction	0.35	Site soil analyses
Soil Bulk Density	p_b	g/cm3	1.7225	ACT 2 TGM Default
Fraction of Organic Carbon	f_{OC}	decimal fraction	0.005	ACT 2 TGM Default
Time		days	1.00E+99	Steady-State Conditions

Chemical Specific Input Parameters				Data Source
Sim 1				
Contaminant			benzene	
Source Concentration (mg/L)		mg/L	0.0080	4/26/2011
Lambda (per day)		day^{-1}	0.001	PADEP Number Please! 2011
KOC			58	PADEP Number Please! 2011

Output (Distance from Source Where Concentration Equals Respective Ground Water MSC)				
Contaminant	**Starting Concentration (mg/L)**	**GW MSC[1] Non-Residential (mg/L)**	**Predicted Concentration (mg/L)**	**Predicted Distance to Meet Non-Residential GW MSC (Rounded Upward to the Nearest foot)**
Sim 1 - benzene	0.0080	0.005	0.005	**28**

[1] ACT 2 TGM, Appendix A, Table 1 MSC for a Non-residential Used Aquifer with Total Dissolved Solids less than or equal to 2500.

Table G.3
Quick Domenico
Fate and Transport Model Input and Output AOI 10
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

Project	2574601 - Sunoco Philadelphia Refinery
Prepared by	Terrance Stanley
Date Prepared	6/23/2011

Generic Input Parameters				Data Source
Source Identification (or Well ID)			**W-23**	
Sample Date			4/27/2011	
Source Width		ft	100	Delineated LNAPL (100' default if no plume is present)
Source Thickness		ft	60	Estimated from cross-sections DD-DD' & EE-EE'
Longitudinal Dispersivity	A_x	ft	200	From CCR QD Simulations
Transverse Dispersivity	A_y	ft	20.0	Quick Domenico User's Manual
Vertical Dispersivity	A_z	ft	0.0001	Quick Domenico User's Manual
Hydraulic Conductivty	k	ft/day	4.64	Alluvium
Hydraulic Gradient		ft/ft	0.0046	W-31/W-16 April 2011
Porosity		decimal fraction	0.35	Site soil analyses
Soil Bulk Density	p_b	g/cm3	1.7225	ACT 2 TGM Default
Fraction of Organic Carbon	f_{OC}	decimal fraction	0.005	ACT 2 TGM Default
Time		days	1.00E+99	Steady-State Conditions

Chemical Specific Input Parameters				Data Source
Sim 1				
Contaminant			benzene	
Source Concentration (mg/L)		mg/L	0.0120	4/27/2011
Lambda (per day)		day^{-1}	0.001	PADEP Number Please! 2011
KOC			58	PADEP Number Please! 2011

Output (Distance from Source Where Concentration Equals Respective Ground Water MSC)				
Contaminant	**Starting Concentration (mg/L)**	**GW MSC[1] Non-Residential (mg/L)**	**Predicted Concentration (mg/L)**	**Predicted Distance to Meet Non-Residential GW MSC (Rounded Upward to the Nearest foot)**
Sim 1 - benzene	0.0120	0.005	0.005	**50**

[1] ACT 2 TGM, Appendix A, Table 1 MSC for a Non-residential Used Aquifer with Total Dissolved Solids less than or equal to 2500.

Table G.4
Quick Domenico
Fate and Transport Model Input and Output AOI 10
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

Project	2574601 - Sunoco Philadelphia Refinery
Prepared by	Terrance Stanley
Date Prepared	6/23/2011

Generic Input Parameters				Data Source
Source Identification (or Well ID)			**W-28**	
Sample Date			4/27/2011	
Source Width		ft	100	Delineated LNAPL (100' default if no plume is present)
Source Thickness		ft	60	Estimated from cross-sections DD-DD' & EE-EE'
Longitudinal Dispersivity	A_x	ft	200	From CCR QD Simulations
Transverse Dispersivity	A_y	ft	20.0	Quick Domenico User's Manual
Vertical Dispersivity	A_z	ft	0.0001	Quick Domenico User's Manual
Hydraulic Conductivty	k	ft/day	4.64	Alluvium
Hydraulic Gradient		ft/ft	0.0046	W-31/W-16 April 2011
Porosity		decimal fraction	0.35	Site soil analyses
Soil Bulk Density	p_b	g/cm3	1.7225	ACT 2 TGM Default
Fraction of Organic Carbon	f_{OC}	decimal fraction	0.005	ACT 2 TGM Default
Time		days	1.00E+99	Steady-State Conditions

Chemical Specific Input Parameters				Data Source
Sim 1				
Contaminant			chrysene	
Source Concentration (mg/L)		mg/L	0.0020	4/27/2011
Lambda (per day)		day^{-1}	0.000	PADEP Number Please! 2011
KOC			490000	PADEP Number Please! 2011

Output (Distance from Source Where Concentration Equals Respective Ground Water MSC)				
Contaminant	**Starting Concentration (mg/L)**	**GW MSC[1] Non-Residential (mg/L)**	**Predicted Concentration (mg/L)**	**Predicted Distance to Meet Non-Residential GW MSC (Rounded Upward to the Nearest foot)**
Sim 1 - chrysene	0.0020	0.002	0.002	**<1**

[1] ACT 2 TGM, Appendix A, Table 1 MSC for a Non-residential Used Aquifer with Total Dissolved Solids less than or equal to 2500.

Table G.5
Quick Domenico
Fate and Transport Model Input and Output AOI 10
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

Project	2574601 - Sunoco Philadelphia Refinery
Prepared by	Terrance Stanley
Date Prepared	6/23/2011

Generic Input Parameters				Data Source
Source Identification (or Well ID)			**W-31**	
Sample Date			4/26/2011	
Source Width		ft	100	Delineated LNAPL (100' default if no plume is present)
Source Thickness		ft	60	Estimated from cross-sections DD-DD' & EE-EE'
Longitudinal Dispersivity	A_x	ft	200	From CCR QD Simulations
Transverse Dispersivity	A_y	ft	20.0	Quick Domenico User's Manual
Vertical Dispersivity	A_z	ft	0.0001	Quick Domenico User's Manual
Hydraulic Conductivty	k	ft/day	4.64	Alluvium based on site-wide slug testing
Hydraulic Gradient		ft/ft	0.0046	W-31/W-16 April 2011
Porosity		decimal fraction	0.35	Site soil analyses
Soil Bulk Density	p_b	g/cm3	1.7225	ACT 2 TGM Default
Fraction of Organic Carbon	f_{OC}	decimal fraction	0.005	ACT 2 TGM Default
Time		days	1.00E+99	Steady-State Conditions

Chemical Specific Input Parameters				Data Source
Sim 1				
Contaminant			benzene	
Source Concentration (mg/L)		mg/L	0.0100	4/26/2011
Lambda (per day)		day^{-1}	0.001	PADEP Number Please! 2011
KOC			58	PADEP Number Please! 2011
Sim 2				
Contaminant			chrysene	
Source Concentration (mg/L)		mg/L	0.0040	4/26/2011
Lambda (per day)		day^{-1}	0.000	PADEP Number Please! 2011
KOC			490000	PADEP Number Please! 2011
Sim 3				
Contaminant			lead	
Source Concentration (mg/L)		mg/L	0.0060	4/26/2011
Lambda (per day)		day^{-1}	0.000	PADEP Number Please! 2011
KOC			0.000	PADEP Number Please! 2011

Output (Distance from Source Where Concentration Equals Respective Ground Water MSC)				
Contaminant	**Starting Concentration (mg/L)**	**GW MSC[1] Non-Residential (mg/L)**	**Predicted Concentration (mg/L)**	**Predicted Distance to Meet Non-Residential GW MSC (Rounded Upward to the Nearest foot)**
Sim 1 - benzene	0.0100	0.005	0.005	**40**
Sim 2 - chrysene	0.0040	0.002	0.002	**1**
Sim 3 - lead	0.0060	0.005	0.005	**32**

[1] ACT 2 TGM, Appendix A, Table 1 MSC for a Non-residential Used Aquifer with Total Dissolved Solids less than or equal to 2500.

Table G.6
Quick Domenico
Fate and Transport Model Input and Output AOI 10
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

Project	2574601 - Sunoco Philadelphia Refinery
Prepared by	Terrance Stanley
Date Prepared	6/23/2011

Generic Input Parameters				Data Source
Source Identification (or Well ID)			**W-32**	
Sample Date			4/27/2011	
Source Width		ft	100	Delineated LNAPL (100' default if no plume is present)
Source Thickness		ft	60	Estimated from cross-sections DD-DD' & EE-EE'
Longitudinal Dispersivity	A_x	ft	200	From CCR QD Simulations
Transverse Dispersivity	A_y	ft	20.0	Quick Domenico User's Manual
Vertical Dispersivity	A_z	ft	0.0001	Quick Domenico User's Manual
Hydraulic Conductivty	k	ft/day	4.64	Alluvium
Hydraulic Gradient		ft/ft	0.0046	W-31/W-16 April 2011
Porosity		decimal fraction	0.35	Site soil analyses
Soil Bulk Density	ρ_b	g/cm3	1.7225	ACT 2 TGM Default
Fraction of Organic Carbon	f_{OC}	decimal fraction	0.005	ACT 2 TGM Default
Time		days	1.00E+99	Steady-State Conditions

Chemical Specific Input Parameters				Data Source
Sim 1				
Contaminant			benzene	
Source Concentration (mg/L)		mg/L	0.0560	4/27/2011
Lambda (per day)		day^{-1}	0.001	PADEP Number Please! 2011
KOC			58	PADEP Number Please! 2011
Sim 2				
Contaminant			chrysene	
Source Concentration (mg/L)		mg/L	0.0040	4/27/2011
Lambda (per day)		day^{-1}	0.000	PADEP Number Please! 2011
KOC			490000	PADEP Number Please! 2011

Output (Distance from Source Where Concentration Equals Respective Ground Water MSC)				
Contaminant	**Starting Concentration (mg/L)**	**GW MSC[1] Non-Residential (mg/L)**	**Predicted Concentration (mg/L)**	**Predicted Distance to Meet Non-Residential GW MSC (Rounded Upward to the Nearest foot)**
Sim 1 - benzene	0.0560	0.005	0.005	**147**
Sim 2 - chrysene	0.0040	0.002	0.002	**1**

[1] ACT 2 TGM, Appendix A, Table 1 MSC for a Non-residential Used Aquifer with Total Dissolved Solids less than or equal to 2500.

Table G.7
Quick Domenico
Fate and Transport Model Input and Output AOI 10
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

Project	2574601 - Sunoco Philadelphia Refinery
Prepared by	Terrance Stanley
Date Prepared	6/23/2011

Generic Input Parameters				Data Source
Source Identification (or Well ID)			**W-33**	
Sample Date			4/27/2011	
Source Width		ft	100	Delineated LNAPL (100' default if no plume is present)
Source Thickness		ft	60	Estimated from cross-sections DD-DD' & EE-EE'
Longitudinal Dispersivity	A_x	ft	200	From CCR QD Simulations
Transverse Dispersivity	A_y	ft	20.0	Quick Domenico User's Manual
Vertical Dispersivity	A_z	ft	0.0001	Quick Domenico User's Manual
Hydraulic Conductivty	k	ft/day	4.64	Alluvium
Hydraulic Gradient		ft/ft	0.0046	W-31/W-16 April 2011
Porosity		decimal fraction	0.35	Site soil analyses
Soil Bulk Density	ρ_b	g/cm3	1.7225	ACT 2 TGM Default
Fraction of Organic Carbon	f_{OC}	decimal fraction	0.005	ACT 2 TGM Default
Time		days	1.00E+99	Steady-State Conditions

Chemical Specific Input Parameters				Data Source
Sim 1				
Contaminant			benzene	
Source Concentration (mg/L)		mg/L	0.2500	4/24/2011
Lambda (per day)		day^{-1}	0.001	PADEP Number Please! 2011
KOC			58	PADEP Number Please! 2011
Sim 2				
Contaminant			chrysene	
Source Concentration (mg/L)		mg/L	0.0060	40657.0000
Lambda (per day)		day^{-1}	0.000	PADEP Number Please! 2011
KOC			490000	PADEP Number Please! 2011
Sim 3				
Contaminant			naphthalene	
Source Concentration (mg/L)		mg/L	0.3300	40657.0000
Lambda (per day)		day^{-1}	0.003	PADEP Number Please! 2011
KOC			950	PADEP Number Please! 2011

Output (Distance from Source Where Concentration Equals Respective Ground Water MSC)				
Contaminant	**Starting Concentration (mg/L)**	**GW MSC[1] Non-Residential (mg/L)**	**Predicted Concentration (mg/L)**	**Predicted Distance to Meet Non-Residential GW MSC (Rounded Upward to the Nearest foot)**
Sim 1 - benzene	0.2500	0.005	0.005	**255**
Sim 2 - chrysene	0.0060	0.002	0.002	**2**
Sim 3 - naphthalene	0.3300	0.100	0.100	**16**

[1] ACT 2 TGM, Appendix A, Table 1 MSC for a Non-residential Used Aquifer with Total Dissolved Solids less than or equal to 2500.

Table G.8
Quick Domenico
Fate and Transport Model Input and Output AOI 10
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

Project	2574601 - Sunoco Philadelphia Refinery
Prepared by	Terrance Stanley
Date Prepared	6/23/2011

Generic Input Parameters				Data Source
Source Identification (or Well ID)			**W-34**	
Sample Date			4/27/2011	
Source Width		ft	100	Delineated LNAPL (100' default if no plume is present)
Source Thickness		ft	60	Estimated from cross-sections DD-DD' & EE-EE'
Longitudinal Dispersivity	A_x	ft	200	From CCR QD Simulations
Transverse Dispersivity	A_y	ft	20.0	Quick Domenico User's Manual
Vertical Dispersivity	A_z	ft	0.0001	Quick Domenico User's Manual
Hydraulic Conductivty	k	ft/day	4.64	Alluvium
Hydraulic Gradient		ft/ft	0.0046	W-31/W-16 April 2011
Porosity		decimal fraction	0.35	Site soil analyses
Soil Bulk Density	ρ_b	g/cm3	1.7225	ACT 2 TGM Default
Fraction of Organic Carbon	f_{OC}	decimal fraction	0.005	ACT 2 TGM Default
Time		days	1.00E+99	Steady-State Conditions

Chemical Specific Input Parameters				Data Source
Sim 1				
Contaminant			benzene	
Source Concentration (mg/L)		mg/L	0.0120	4/27/2011
Lambda (per day)		day^{-1}	0.001	PADEP Number Please! 2011
KOC			58	PADEP Number Please! 2011

Output (Distance from Source Where Concentration Equals Respective Ground Water MSC)				
Contaminant	**Starting Concentration (mg/L)**	**GW MSC[1] Non-Residential (mg/L)**	**Predicted Concentration (mg/L)**	**Predicted Distance to Meet Non-Residential GW MSC (Rounded Upward to the Nearest foot)**
Sim 1 - benzene	0.0120	0.005	0.005	**50**

[1] ACT 2 TGM, Appendix A, Table 1 MSC for a Non-residential Used Aquifer with Total Dissolved Solids less than or equal to 2500.

Table G.9
Fate and Transport Model Input and Output AOI 10
Sunoco Philadelphia Refinery
Philadelphia, Pennsylvania

Well ID	Compound	Starting Concentration	Final Concentration (Screening Value)	Predicted Distance to Achieve Screening Value	Estimated Distance to AOI 10 Boundary
		ug/l	ug/l	ft	ft
W-1	benzene	20	5	80	90
W-12	benzene	8	5	28	105
W-23	benzene	12	5	50	98
W-28	chrysene	2	1.9	<1	180
W-31	benzene	10	5	40	270
	chrysene	4	1.9	1	
	lead	6	5	32	
W-32	benzene	56	5	147	170
	chrysene	4	1.9	1	
W-33	benzene	250	5	**255**	90
	chrysene	6	1.9	2	
	napthalene	330	100	16	
W-34	benzene	12	5	50	130

Note:
= indicates predicted distance is greater than distance to property boundary